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In Vitro Assessment of Abrasion Resistance of Two Different Artificial Teeth after Brushing With Different Commercially Available Cleansing Agents

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Abstract

The selection of appropriate denture cleansing agents is essential to maintain the integrity and longevity of acrylic resin teeth used in removable prostheses. The aim of this study is to identify the most effective denture cleansing agents that minimize abrasion on two types of acrylic teeth, Surana (PMMA with cross linked polymer matrix) and Biorock VXL(PMMA), while maintaining their surface integrity.

Aims: To determine which denture cleansing agent has the least abrasive effect on the acrylic teeth used in the study.

Objectives

- To evaluate and compare the abrasion caused by:
- Palmolive soap on Surana and Biorock VXL.
- Clanden denture cleansing paste on Surana and Biorock VXL.
- Pepsodent paste on Surana and Biorock VXL.
- Water on Surana and Biorock VXL.

To assess which of the two acrylic teeth Surana or Biorock VXL demonstrates greater resistance to abrasion when subjected to these denture cleansing agents.

Materials and Methods: This study utilized two types of acrylic teeth: Surana(by Heracryl) and Biorock VXL (by Burlon). The cleansing agents included Palmolive soap, Pepsodent paste, Clanden denture cleansing paste, and distilled water. Abrasio n resistance was evaluated through a one way ANOVA and Tukey's post hoc test to identify significant differences in material loss.

Results: For both Surana and Biorock teeth, Pepsodent paste caused the highest material loss due to abrasion, followed by Clanden denture paste, Palmolive soap, and water, which caused the least abrasion. Overall, Surana teeth exhibited superior abrasion resistance compared to Biorock VXL.

Conclusions: The study concluded that Surana teeth showed greater resistance to abrasion compared to Biorock VXL teeth. Pepsodent paste was found to be the most abrasive cleansing agent, while water caused the least abrasion. These findings guide dental professionals in selecting suitable denture cleansing agents and acrylic teeth materials to enhance prosthetic durability.

Keywords: Artificial teeth, Cleansing agent, Acrylic resin teeth, Oral health

Introduction

Acrylic resin artificial teeth are the preferred choice for removable prostheses due to their strong bond with denture bases, aesthetic appeal, and versatility. However, these materials face limitations, especially in terms of abrasion resistance and susceptibility to fractures. Recent advancements aim to enhance the wear resistance, appearance, and ease of manufacturing acrylic teeth, notably with innovations like Interpenetrated Polymer Network (IPN) technology, which has shown improved resistance to fracture, abrasion, and staining compared to traditional acrylic teeth.[3-4]

Abrasion resistance is critical to maintaining the occlusal vertical dimension, a key factor in prosthetic success.[5]Artificial teeth with poor abrasion resistance can lead to functional and aesthetic problems, including inefficient chewing, craniofacial disorders, muscle fatigue, and patient discomfort. Therefore, improving the abrasion resistance of acrylic resin teeth remains a priority for durable prosthetic treatments.[1-3]

Denture cleaning, a routine maintenance process, involves brushing that can lead to surface wear of the denture materials. Factors such as the abrasiveness of denture cleansers, the stiffness of toothbrush bristles, and the frequency of brushing contribute to the wear on acrylic resin teeth.[5,6]Most patients use dentifrices, but their abrasive ingredients may increase surface roughness and compromise the tooth structure. Alternatives like soap, which are non-abrasive and affordable, have gained attention, though research on their effects on denture materials is limited.[8,9]

This study investigates the impact of various denture cleansing agents on the abrasion resistance of two types of acrylic resin teeth—Biorock and Surana. The goal is to offer insights that assist dental professionals in selecting both denture materials and appropriate cleansers to maximize the longevity of dentures while minimizing abrasion-related wear.[3,18-21]

In summary, the study aims to explore the relationship between denture cleansing agents and the wear resistance of acrylic resin teeth, with the ultimate goal of improving denture durability and maintaining oral health in prosthetic patients.

Material and Methodology

Source of Data: This in vitro study was conducted at the Department of Mechanical Engineering, G.L. Bajaj Institute, Mathura.

Data Collection:

Sample Size: The sample size was calculated based on a 99% confidence level, 80% power, and an alpha level of 0.05 using the following formula:

Sample Size= $$Z = 2 \times \frac{(Z_\beta + Z_\beta)^2}{(\delta_0)^2} \times SD^2$$

With the above calculations, a sample size of 8 was determined for each group.

Type of Study: This is an in vitro study.

Methodology

Preparation of Samples:

Each group consisted of twelve teeth (n=12), comprising the second premolars and the first and second molars from both the right and left sides of the maxillary and mandibular arches. The teeth were reduced to the ridge lap area using a silicon carbide bur and subsequently cleaned with tap water. Following this, they were stored at 37°C in tap water for seven days. After the incubation period, the teeth were gently dried with tissue paper and weighed using a precision weighing machine to record their initial weight.

Brushing Procedure: A mechanical brushing apparatus was employed, fitted with a Clinodent Denture Brush. The brushing was performed with a vertical load of 200g applied to the occlusal surfaces of each tooth. The brushing cycle involved 11,000 strokes to simulate one year of brushing, with strokes focused on the occlusal areas.

Figure 1: Mechanical Brushing Machine
(Shaper Machine)
(Simulate Manual Brushing)

Figure 2: The Way Brusing Was Performend:

Figure 3:
Due To Brushing the Form Formed
Due to the Presence of Sodium
Lauryl Sulfate (Surfactant)

Post-Brushing Measurement: After completing the brushing cycles, the teeth were carefully removed from the plaster of Paris (POP) blocks, which provided support during the brushing process. They were then cleaned and re-weighed to measure material loss due to abrasion. This process allowed for a precise evaluation of the wear on the artificial teeth caused by mechanical brushing.

Cleansing Agents and Abrasive Content Testing: The study also assessed the cleansing agents used in the brushing process—Palmolive soap, Clanden denture cleansing paste, Pepsodent paste, and water—to determine the amount of abrasive particles they contained. This analysis is critical for understanding the extent of material loss from the artificial teeth due to the use of these agents.

Experimental Groups

Group A: Biorock VXL

Group B: Surana

Each group was subjected to the same experimental conditions, with the amount of material lost due to abrasion recorded and compared to evaluate the abrasive resistance of the two types of acrylic resin teeth and the impact of different cleansing agents.

Statistical Analysis

The collected data was coded, tabulated, and analyzed using various statistical methods to explore relationships between variables across different study groups.

Statistical Tests Used

- One-way ANOVA
- Tukey's post hoc test

One-way ANOVA: One-way ANOVA is a parametric test used to determine if there is a statistically significant difference between the means of two or more independent groups. It helps assess whether variations in group means are due to random chance or represent actual differences. The key elements in the test include:

Dependent variable: Continuous (interval or ratio level)

Independent variable: Categorical (two or more groups)

Assumptions: Independent observations, random sample selection, normal distribution of the dependent variable, and sufficient sample size.

The ANOVA test calculates:

F-statistic (F): Represents the ratio of variance between groups to variance within groups.

MST (Mean Square Between Groups): Reflects the variation between the groups.

MSE (Mean Square Error): Represents the variation within the groups.

The test outputs whether significant differences exist among group means but does not specify which groups differ.

Tukey's Post Hoc Test: Post hoc tests are conducted after ANOVA to pinpoint which specific group pairs differ. Tukey's test is a widely used method for comparing all possible group combinations, controlling the experiment-wise error rate at 0.05. It calculates the **q-statistic**, a modified t-statistic for multiple comparisons, using the formula:

$$q_s = \frac{Y_{\max} - Y_{\min}}{SE}$$

Where:

- Ymax and Ymin are the group means.
- SE (Standard Error): Reflects the design's standard error.

Tukey's test helps identify specific group differences while ensuring the overall error rate remains controlled.

Results

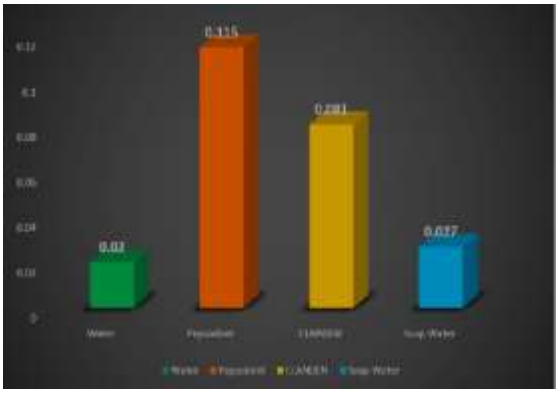
The study was conducted to evaluate the effect of different denture cleansing agents on the abrasion resistance of two types of acrylic teeth: Surana (by Heracryl, a synthetic polymer based on polymethyl methacrylate) and Biorock VXL (by Burlon, acrylic teeth based on polymethyl methacrylate). The cleansing agents tested were Water, Pepsodent, CLANDEN, and Soap Water. Each tooth was exposed to 11,000 brushing strokes (~1 year of brushing) with Clinodent Denture Brush under a load of approximately 200g. The weight

loss of the teeth before and after brushing was recorded to measure the abrasion caused.

Surana Group

- The highest material loss due to abrasion was observed with Pepsodent (0.115±0.080 gm), followed by CLANDEN (0.081±0.071 gm), Soap Water (0.027±0.013 gm), and the least abrasion occurred with Water (0.020±0.031 gm).
- One-way ANOVA revealed significant differences between groups (F = 7.75, p = 0.001), indicating that the cleansing agent used had a notable effect on the material lost.
- Post hoc testing showed significant differences between all pairs of subgroups, confirming that Pepsodent caused the most abrasion, while Water caused the least.

Graph 1 illustrates the material lost due to abrasion, where Pepsodent caused the highest loss (0.115 gm), followed by CLANDEN (0.081 gm), Soap Water (0.027 gm), and Water (0.020 gm).

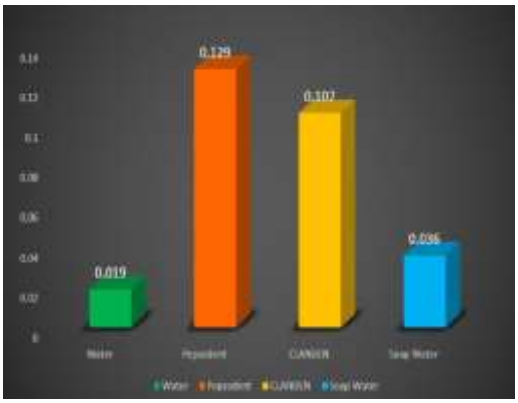


Graph 1:

Biorock Group

- Similar to the Surana group, the highest material loss was recorded with Pepsodent (0.129±0.031 gm), followed by CLANDEN (0.107±0.008 gm), Soap Water (0.036±0.006 gm), and the least abrasion with Water (0.019±0.007 gm).
- One-way ANOVA confirmed significant differences between groups (F = 7.75, p = 0.001).
- Post hoc tests indicated significant differences between all pairs of subgroups, with Pepsodent causing the most abrasion and Water causing the least.

Graph 2 displays the material loss, with Pepsodent showing the highest material loss (0.129 gm), followed by CLANDEN (0.107 gm), Soap Water (0.036 gm), and Water (0.019 gm).

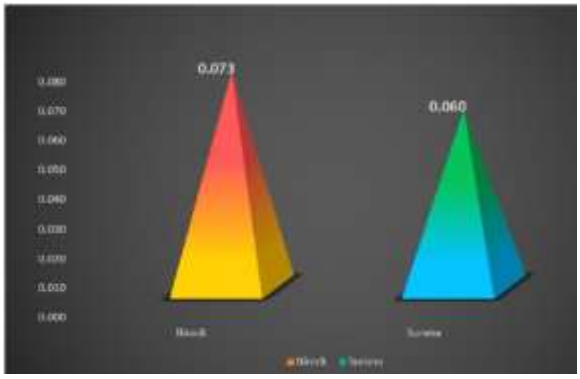


Graph 2:

Inter-Group Comparison

- The total material loss due to abrasion was higher in the Biorock group (0.073±0.09 gm) compared to the Surana group (0.060±0.07 gm).
- The student t-test showed a significant difference between the groups (t = 4.98, p = 0.001), confirming that Biorock acrylic teeth experienced greater material loss compared to Surana.
- Therefore, Surana teeth demonstrated greater abrasion resistance than Biorock teeth

Graph 3 compares the material loss between the two groups, showing greater abrasion in Biorock (0.073 gm) than in Surana (0.060 gm).



Graph 3:

Conclusion

- Pepsodent caused the most significant abrasion in both types of acrylic teeth, while Water caused the least.
- Surana acrylic teeth exhibited better abrasion resistance than Biorock, making them more durable under similar conditions.

Discussion

This study aimed to evaluate the abrasive resistance of two types of artificial teeth, PMMA-based (Biorock VXL) and interpenetrating-polymer network (IPN)-based (Surana), when subjected to different denture cleansing agents. The findings shed light on the importance of selecting appropriate artificial teeth and cleansing agents to enhance the longevity of dental prostheses, thereby improving patient comfort and oral health.

The results clearly indicated that IPN teeth (Surana) exhibited greater abrasion resistance compared to PMMA teeth (Biorock VXL). The superior wear resistance of IPN teeth can be attributed to their unique cross linked polymer structure, which enhances their mechanical strength and resilience. These findings are consistent with the literature, which shows that IPN materials generally perform better in terms of fracture resistance and durability than traditional acrylic-based teeth[1–4].

Regarding the denture cleansing agents, Pepsodent caused the most significant abrasion, followed by Clanden denture cleansing paste, Palmolive soap, and water, which had the least abrasive effect. The high abrasiveness of Pepsodent can be linked to its inclusion of hydrated silica particles, a common abrasive component in many dentifrices. Previous studies have confirmed that silica and calcium carbonate, both frequently found in toothpaste, contribute to increased wear on denture materials[31–35].

Interestingly, Palmolive soap showed minimal abrasion, which can be explained by its formulation, free from harsh abrasive particles. Its primary ingredients, such as sodium palmate and glycerin, offer cleansing properties without causing significant mechanical wear. This suggests that Palmolive soap could be a suitable alternative to traditional dentifrices for patients who wear dentures, as it provides effective cleaning while minimizing material loss.

These findings align with prior research by Vivian Barnabe Policastro et al., who observed greater abrasion with toothpaste compared to coconut soap or water, regardless of the type of artificial teeth used[23]. Similarly, D.J. Whitman et al. found that IPN and microfilled composite (MC) denture teeth exhibit superior wear resistance compared to traditional acrylic resin (AR), maintaining their integrity even in challenging environments like ethanol solutions[11]. This highlights the advantages of newer, advanced materials like IPN over conventional acrylic resin teeth, especially in terms of their long-term performance in the oral environment.

Moreover, J.P. Coffey et al. demonstrated that IPN teeth possess enhanced wear resistance compared to acrylic resin teeth when functioning against one another. Their study further reinforced the idea that modern denture materials like IPN are more durable in functional

occlusion scenarios, which can significantly benefit patients in terms of prosthesis longevity[18].

The study also emphasized the necessity of proper denture care and cleaning. Denture cleaning agents are essential for maintaining the hygiene and aesthetics of removable prostheses, but the abrasive nature of these agents must be carefully considered. As demonstrated, excessive abrasiveness can compromise the structural integrity of artificial teeth, leading to early wear and potential discomfort for the patient. In this context, mild cleansing agents like Palmolive soap, which do not contain silica or calcium carbonate, are preferable.

Finally, while artificial brushing may exaggerate the effects of abrasion compared to manual brushing, the study's methodology mirrors the long-term impact of daily denture cleaning. Considering the recommended replacement of dentures every 5 to 7 years, this study offers valuable insights into how patients can prolong the life of their prostheses through the selection of appropriate cleaning materials and techniques[5].

In conclusion, IPN teeth are more resistant to abrasion than PMMA teeth, and cleansing agents without abrasive particles like hydrated silica are less likely to damage denture materials. Based on this study, Palmolive soap stands out as a suitable denture cleansing agent, providing a balance between effective cleaning and minimal abrasion. These findings can guide dental professionals in recommending appropriate artificial teeth and denture cleansing practices, ultimately enhancing patient outcomes and the durability of removable dentures.

Conclusion

In summary, this study highlights significant findings regarding the abrasive resistance of different artificial teeth and the impact of various denture cleansing agents. The results indicate that Palmolive soap exerts the mildest abrasive effect on SURANA (IPN) teeth compared to BIOROCK VXL (PMMA), suggesting that it is a more suitable cleansing option for maintaining the integrity of IPN dentures.

Additionally, Clanden denture cleansing paste was found to be less abrasive on SURANA than on BIOROCK VXL, reinforcing its effectiveness as a gentler cleaning alternative. Furthermore, Pepsodent paste, while widely used, demonstrated a higher concentration of abrasive particles, leading to increased wear on both types of teeth, particularly BIOROCK VXL.

Ultimately, the findings affirm that SURANA (IPN) teeth exhibit superior abrasion resistance compared to conventional BIOROCK VXL (PMMA) teeth. This study underscores the importance of selecting appropriate denture materials and cleansing agents to enhance the longevity and durability of removable prostheses, thereby contributing to improved patient satisfaction and comfort. The insights gained from this research provide valuable guidance for dental professionals in optimizing oral care practices for denture wearers.

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